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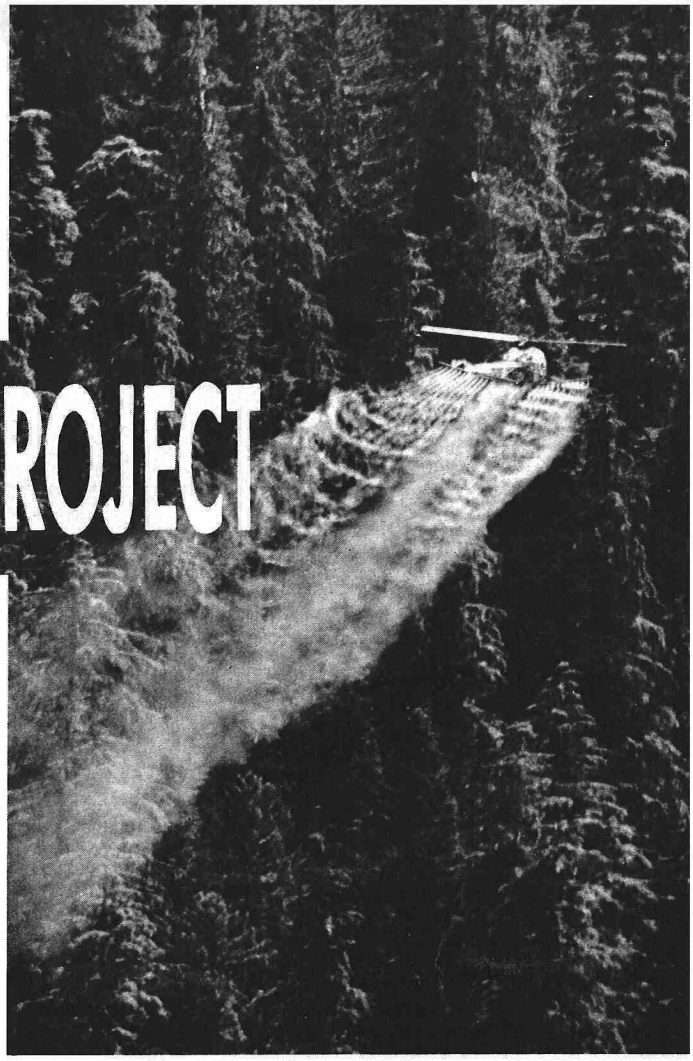
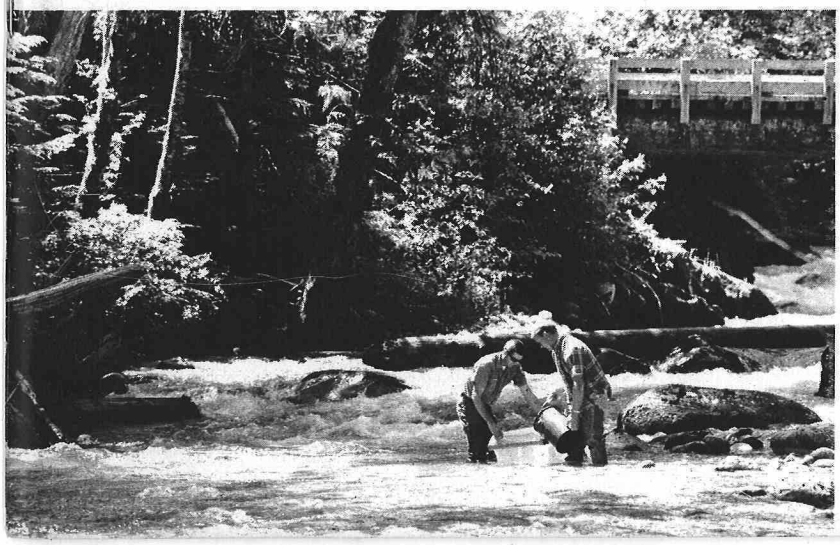
HEMLOCK LOOPER PROJECT



MOUNT BAKER NATIONAL FOREST

INSECT AND DISEASE CONTROL BRANCH
DIVISION OF TIMBER MANAGEMENT
PACIFIC NORTHWEST REGION
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE



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1968 HEMLOCK LOOPER PROJECT
Mt. Baker National Forest
Washington

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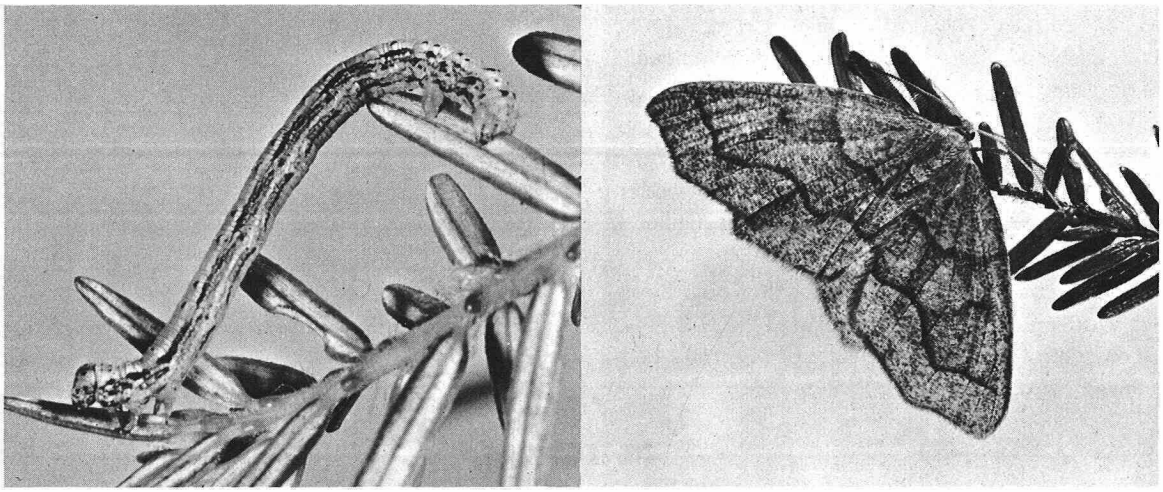
INTRODUCTION

The 1967 aerial detection survey revealed heavy defoliation of western hemlock by the western hemlock looper, *Lambdina fiscellaria lugubrosa* Hulst, (figure 1) in the Bacon Creek drainage, Mt. Baker National Forest, Washington. Fall egg surveys showed high looper egg numbers in the Bacon Creek outbreak as well as several other widely scattered areas showing no visible defoliation.



Mature larva Adult

Figure 1.—Western hemlock looper larva and adult on western hemlock twigs.

Because of the possibility of future hemlock looper outbreaks that may require control, the decision was made to conduct a pilot study of several insecticides to find an effective substitute for DDT to control this defoliator. Based on the recommendation of the Insecticide Evaluation Unit of the Pacific Southwest Forest and Range Experiment Station, it was decided to test several helicopter-applied formulations of Zectran and Malathion. The decision was also made to try a new type of spray system, hereafter referred to as the aerosol spray system, developed by the Missoula Equipment Development Center (MEDC).

Because of lack of infested areas with the proper topography to meet standards set up for the aerosol spray system, the original plan to spray three areas of 1,000 acres each was scaled down. Spraying was eventually done on 500 acres, with one formulation of Zectran, a nonpersistent carbamate insecticide (4-dimethylamino-3,5-xylyl methylcarbamate) carried in Dowanol TPM (tripropylene glycol methyl ether), in the watershed of Sonny Boy Creek, tributary to the Cascade River.

The project was organized and administered by the Region 6 Insect and Disease Control Branch, Division of Timber Management of the U.S. Forest Service, assisted by the Mt. Baker National Forest. Technical assistance in monitoring the project for effects on fish and other aquatic organisms was provided by the Branch of Wildlife Management and the Division of Watershed Management of the U.S. Forest Service and the State of Washington Departments of Fisheries, Pollution Control, and Game. Overall supervision of the project was by Benton Howard, Chief, Branch of Insect and Disease Control, Division of Timber Management. Jack Mounts, Forester, was Project Director and the Project Entomologist was Leon F. Pettinger, both of the Insect and Disease Control Branch.

This report summarizes the organization, procedures, and results of the 1968 Hemlock Looper Project on the Mt. Baker National Forest in Washington.

HISTORY AND BACKGROUND

The western hemlock looper is a very destructive defoliator of the spruce-hemlock forests along the coasts of Oregon, Washington and British Columbia. During the past 75 years, six major epidemics and several minor ones have occurred. Epidemics are not limited to the coastal areas, having occurred as far east as the Inland Empire of eastern Washington and northern Idaho. Hemlock is the preferred host, but during epidemics anything green is devoured.

In 1962 a cooperative project was undertaken by the State of Oregon, Forest Industry, and the U.S. Forest Service to control a serious infestation of the western hemlock looper on 32,531 acres of hemlock timber in Clatsop County in northwestern Oregon. (2)

In 1963 another cooperative project was held by the State of Washington, Forest Industry, and the U.S. Forest Service to control an infestation of about 57,500 acres in southwest Washington near Willapa Bay. Furthermore, private industry sprayed an additional 14,810 acres in this same area. (5)

The history of hemlock looper indicates that outbreaks tend to occur about every 5 to 13 years with an average of about 8 years. Outbreaks seem to last about 3 to 4 years before natural enemies reduce the populations to endemic levels.

In previous control efforts, DDT has been the only control agent, with the exception of the Willapa Bay outbreak where the insecticide Sevin was also used. Tests were also made on phosphamidon and a biological agent *Bacillus thuringiensis*, on the Willapa Bay outbreak (1,4). Except for DDT, none of the above agents proved effective against the hemlock looper. Because of its long-lasting effects, the search continues for an acceptable, effective, and economical control agent to use in place of DDT.

OBJECTIVES

The objectives of this pilot test were twofold:

1. To determine the effectiveness of Zectran as a control agent for the western hemlock looper.
2. To determine whether the aerosol method of spraying, in its present stage of development, was practical under certain forest conditions.

BIOLOGICAL PHASES

Detection Surveys in Preparation

Egg detection surveys.—After the discovery of the heavy defoliation in Bacon Creek during the summer of 1967, overwintering egg numbers were sampled to determine the extent of the outbreak and to help find areas suitable for the pilot test. Egg samples were taken from all major drainages on the Forest between October 1 and December 1.

The detection survey was made by collecting moss samples from tree boles, low hanging branches, and understory growth. Eggs were extracted in the laboratory from approximately 1 pound of dry moss, using the procedure described by Buffam for the 1968 western hemlock looper egg survey in southwest Washington (5). Areas where samples contained more than 40 eggs per pound of dry moss which were classified as high risk, included Clear Creek, Finney Creek, Upper Cascade River, Bacon Creek, Baker River, Rockport State Park and Boulder Creek.

Only two of these areas developed high looper populations during the summer of 1968. Bacon Creek continued the high population count and the Upper Cascade River developed high populations in localized areas such as Sonny Boy Creek. The other high-risk areas, based on the egg surveys, did not develop looper numbers suitable for a pilot test.

Larval detection surveys.—As soon as it was determined that all looper eggs had hatched, larval surveys were made to determine the actual populations. Surveys were made in all major drainages with heavy emphasis placed on those drainages classified as high-risk areas on the basis of egg numbers.

Larval counts were made by clipping 18-inch branches from mid- and lower crowns of several western hemlock trees. Larvae were counted and averages determined per branch. Bacon Creek and the Upper Cascade River were the only areas of those classified as high risk from the egg survey which contained looper populations sufficiently high to permit a valid pilot test of Zectran. Bacon Creek, however, could not be used because of its proximity to the then existent North Cascades Primitive Area, which became a National Park in December 1968.

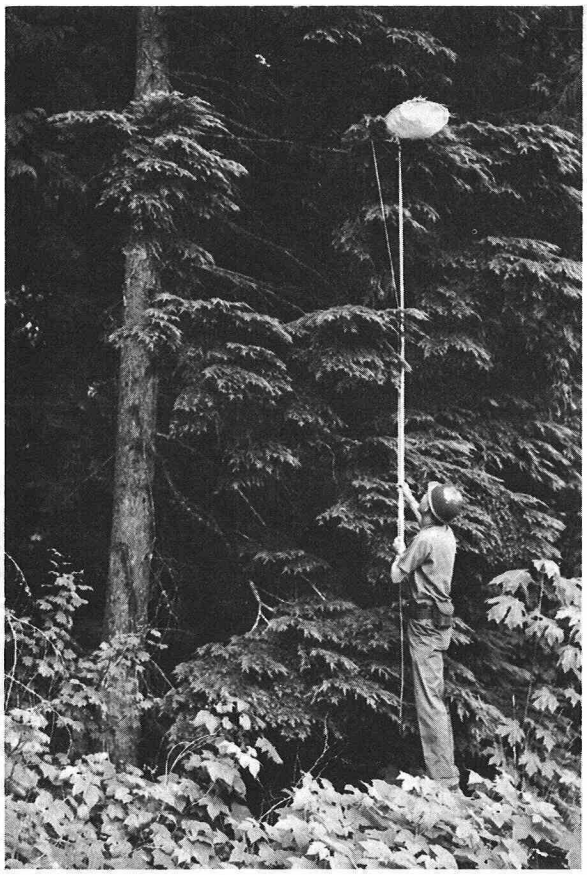


Figure 2.—Pole pruner being used to clip 18-inch branch from sample tree.

Figure 3.—Hemlock looper larvae being shaken from sample branch on to cloth basket.

Mortality Evaluation

Larval sampling.—Evaluation of the Zectran-caused mortality was made by sampling larvae in the spray test area 1 day before spraying and 3 days after spraying. Prespray and postspray samples were taken on 24 plots within the spray area.

1. **Prespray larval sampling:** Prespray larval sampling was done on July 22, 1 day before spraying. Sampling plots were distributed at a distance of 50- to 100-yard intervals along three lines across the lower portion of the spray area. Original plans specified that samples be taken along four lines across the spray area, but the earlier detection surveys showed that the looper population in the upper portion of the Sonny Boy Creek watershed was not heavy enough to permit reasonably accurate sampling.

   Each sample consisted of two 18-inch branches from each of three western hemlock trees. The branches were taken as near to mid-crown as could be reached with a 20- to 25-foot aluminum pole pruner (figure 2). In order to prevent dislodging any larvae while the branch was lowered to the ground, each clipped branch was caught and held in a muslin basket attached to the cutting head of the pruner (figure 3). The larvae were counted on each branch and preserved in 70% alcohol for instar determination at a later date. In addition, all hemlock sawfly and black-headed budworm larvae on each sample were counted and recorded as "other insects."

   At the time the prespray count was made, the three trees on a sample plot were marked to enable identification and sampling the same trees during the postspray sampling. Each tree was marked with a 3 x 8 inch highly visible flame-orange or yellow fluorescent cloth tag. The line number, plot number and tree number were

written on each tag (figure 4). The flame-orange was more visible and resulted in less searching for plots and trees during the postspray sampling.

2. **Postspray larval sampling.**—Postspray larval counts were made 3 days after spraying, on July 26. The counts were made by sampling the same trees included in the prespray count. All looper larvae were counted, recorded, and preserved in 70% alcohol. Black-headed budworm and hemlock sawfly larvae were also counted and preserved.

Mortality drop sheets.—Plastic sheets spread under trees were used as an additional means of mortality assessment. Sheets were placed under trees on 11 of the sample plots to catch falling larvae affected by the Zectran spray. The sheets were 3 x 3 feet and were suspended 2 to 3 feet above the ground by the four corners. A small stone was placed in the center of each sheet to take up the slack and prevent the plastic from fluttering in the wind.

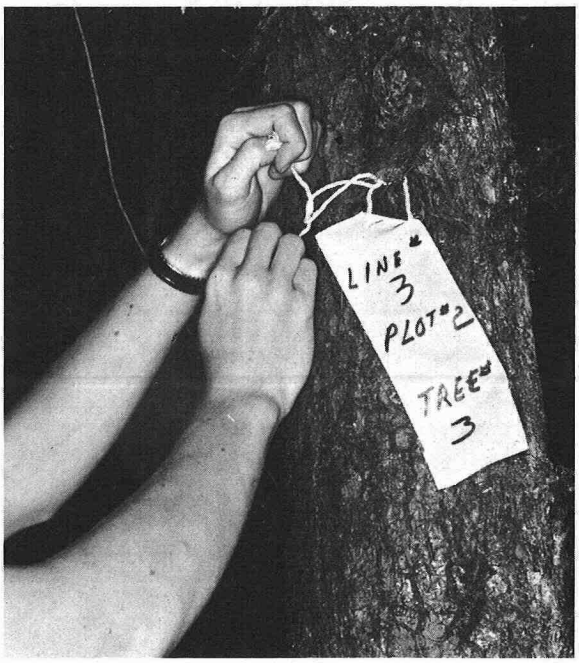


Figure 4.—Example of fluorescent tags used to mark sample trees in plots.

Spray Deposit Evaluation

The fact that there would be problems in spray deposit evaluation was realized early in the planning of the pilot test. No satisfactory method has yet been developed for field recording of the extremely small droplet size dispensed by the aerosol spray system. Laboratory tests showed that the addition of fluorescing dye tracers to the Zectran would permit detection of droplets ranging in diameter from 50 to 75 microns on a plain white card under ultraviolet light. However, compatibility of the dye tracer with either Zectran or the spray delivery system could not be assured. Rather than risk a malfunction of the spray delivery system or a change in the toxicity of the Zectran, the fluorescing dye tracer technique was not used. See results section of this report for results of spray deposits.

Two additional types of spray deposit cards were tested. One was the oil-sensitive dye card commonly used with DDT in oil and the other was a plain, clear plastic card. Spray droplets with diameters greater than 250 microns could be detected on both. Spread factors for the Zectran spray droplets were not determined for either type of card. Realizing that the chance of recording any spray deposit was small and that no reliable estimate of actual volume of Zectran applied could be made, the decision was still made to use both types of cards in the pilot test.

Eighteen each of the plastic and oil-sensitive dye cards were distributed on eleven sample plots through the spray area. The plastic and oil-sensitive cards were mounted side by side on wire holders about 18 inches above the ground. The cards that were placed near sample plot trees in both natural openings and under the canopy closure were put out the day before spraying when the pre-spray larval count was made.

Stream Monitoring in Conjunction With Pilot Test

On July 12, three live boxes (figures 5 and 6) were placed in Sonny Boy Creek at three separate locations. Stations 1 and 2 were located immediately adjacent to the log stringer bridge crossing Sonny Boy Creek at a point 200 yards upstream from its confluence with the Cascade River. Station 3 was located 60 yards downstream from the bridge. The live boxes used consisted of 2 x 2 x 3 foot wooden frames constructed of 1 x 2 inch wooden stock and lined with nylon bobinetting. The live boxes were placed in the stream so as to be

Figure 5.—Fishery biologists placing silver salmon fingerlings in the live box in Sonny Boy Creek to test for effects of insecticide.

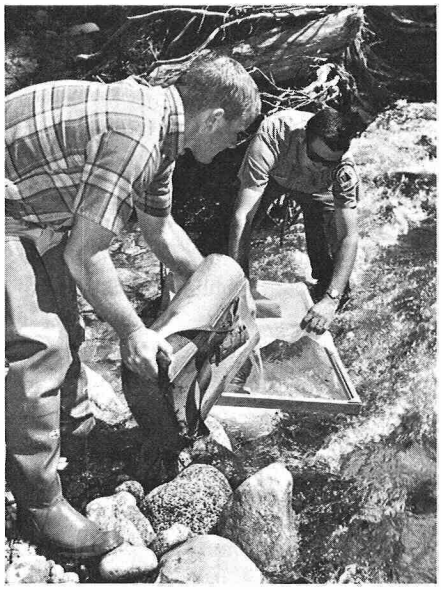


Figure 6.—Fishery biologists placing trout fingerlings in live box in Sonny Boy Creek.

partially shielded from the direct water currents enabling the fish to escape continuous buffeting and to maintain themselves normally in the quieter water.

Hatchery-reared coho salmon, *Oncorhynchus kisutch*, fingerlings (2 to 4 inches) from the nearby Skagit .Hatchery were placed in each of the three live boxes. On July 16, rainbow trout, *Salmo gairdneri*, from the Whatcom Falls Hatchery were added to each box. The trout were in the 4- to 6-inch size range. Approximately 20 fish of each species were placed in each live box.

A control station with one live box was established on Kindy Creek, the basin lying to the west and adjacent to Sonny Boy. The Kindy Creek basin was considered to be representative of conditions in Sonny Boy with the exception of the application of insecticide.

Four sampling stations were set up to determine the effect of possible drift of Zectran on aquatic insects. A prespray count was made of larval aquatic insects July 16. The rocks selected were 6 to 8 inches in diameter, and the insects were counted only once. Five different rocks of the same size range were counted from the same riffles for the postspray insect counts. Mayflies were the most numerous insect forms found. They are generally considered to be one of the most sensitive forms to insecticide drift in water. Very few caddis larvae were observed on sample rocks and there was a complete absence of the rather common stonefly.

Prior to spraying on the morning of July 23, samples of coho salmon and rainbow trout were taken from the live boxes in both Sonny Boy and Kindy Creeks and frozen for possible future chemical analysis. If significant mortalities had occurred, tissue samples taken before and after spraying would have been analyzed by the Washington Department of Fisheries to determine exact causes. There was a minimal loss of test fish in the live boxes within the first 48 hours after placement due to handling and possible injury during transfer from the hatchery to the stream. After the initial 48 hours, however, there were no significant mortalities.

No noticeable effects of spraying were found from a check of the live boxes immediately after spraying.

After rechecking the insect population in the four representative riffles on the 24th and finding no loss of even the smallest of mayflies, it was decided to terminate the stream monitoring. The fact that Zectran changes its chemical composition rather rapidly in the aquatic environment was a factor in deciding to terminate monitoring with no scheduled follow-up studies.

The postspray check made on the aquatic population revealed an increase in the observed population. This increase amounted to an average of 14.2 insects per sample rock as compared to an average of 9.1 insects per sample rock prior to spraying. The increase as observed was probably due in part to growth of the many minute mayfly nymphs into a size range where they were more easily observed and counted.

Results

Larval population changes between prespray and postspray counts.—Data from all the 24 mortality plots revealed a decrease in looper population between the prespray and postspray larval counts of only 20.1 percent. When the data from individual plots were analyzed separately, many of the plots actually showed an increase in looper numbers. Extremes in population changes among all plots ranged from an increase of 80.0 percent to a decrease of 76.2 percent. These extremes in population changes are probably amplified by the low number of larvae on many of the plots.

Population changes between the prespray and postspray counts were determined using the following formula:

$$\text{Percent population change} = \frac{\text{Prespray larval count - postspray larval count}}{\text{Prespray larval count}} \times 100$$

Changes in the hemlock sawfly and black-headed budworm number were also erratic. A total of 107 sawfly and black-headed budworm larvae on all 24 sample plots were counted on the prespray sample, while 135 were counted during the postspray sample. This results in a population increase of 26.2 percent.

Looper development at spray date.—Ninety-two percent of the hemlock looper larvae were in the third and fourth instar on the prespray sampling date. Only 3.4 percent of the larvae had reached the fifth instar. Four days later when the postspray count was made, 76.9 percent were in the third and fourth instar and 21.8 percent had reached the fifth instar (figure 14).

Spray deposit results.—The spray deposit cards were collected the afternoon following spraying. Evaluations made from the cards were inconclusive. Spray deposits could not be detected on any of the clear plastic cards. Of the 18 oil-sensitive dye cards, 8 showed signs characteristic of spray deposits.

It is of interest to note that five of the eight cards showing signs of spray deposit had been placed in natural openings in the stand. The population change on all plots with cards showing no sign of insecticide deposit was an 18.6 percent decrease, whereas, on plots with cards showing some sign of deposit, the population change was a 31.6 percent decrease.

Results of the mortality drop sheets.—The 3 x 3 foot plastic drop sheets were examined the afternoon following spraying and again when the postspray larval count was made. On the afternoon of spraying, many hemlock looper larvae were spinning webs and falling from the trees. These larvae were very much alive and appeared hyperactive as if affected by the Zectran spray. However, at the time of the postspray count, no hemlock looper larvae were found on the plastic sheets. If, in fact, these hyperactive larvae were showing signs of Zectran poisoning on the day of spraying, they had apparently received a sublethal dose and later recovered to crawl off the plastic sheet.

Results of stream monitoring.—The insecticide Zectran, applied aerially by helicopter at the rate of 2.4 pints of 6 percent active material per acre in an aerosol formulation, had no noticeable effect on test fish or aquatic insects in Sonny Boy Creek.

Although time and other factors would not permit a sophisticated study of the total aquatic environment in the Sonny Boy Creek basin, it can be conclusively stated that if any harmful levels of a toxic material had entered the stream system during the spray project, it would have been detected in the tests conducted.

OPERATIONAL PHASE
Advance Preparation

Information and Coordination.—The area involved in the pilot spray project is very sensitive due to its proximity to a primitive area which became a part of the North Cascades National Park in December 1968. In addition, the Cascade and Skagit Rivers are world-famous salmon spawning streams. It was imperative that all possible precautions be taken to protect all of the natural resources including fish, wildlife, and other flora and fauna. Accordingly, the following steps were taken:

a. Approval for use of the chemical spray was requested from the Federal Committee on Pest Control. This approval was received in June 1968.

b. A plan was made by the Insect and Disease Control Branch for informing the public of the project. This, in turn, was followed by a plan prepared by the Mt. Baker National Forest to cover their portion of the job.

c. Several meetings were held with the U.S. Fish and Wildlife Service to discuss needs for monitoring any effects of the chemicals on fish and wildlife habitat. Since they had previously monitored the effects of Zectran on other projects and found it exceptionally safe, they felt there was no need for further monitoring by their Agency.

d. A meeting was held on March 26 with the Washington Department of Fisheries to discuss the project and answer any questions they might have. Due to the precipitous nature of the stream (over 20% grade in its lower reaches) it does not support an anadromous fish population. Its potential for resident fish species and the fact that it is tributary to a major watercourse, however, made it necessary to monitor the effects of any possible insecticide drift on aquatic life in the stream.

e. A joint meeting was held on May 7 with the Washington Departments of Fisheries, Game, and Pollution Control to discuss any questions they might have and the possibility of additional monitoring.

f. Upon establishing with reasonable certainty the location of the experimental insecticide application, a joint meeting was held with the U.S. Forest Service and State of Washington agencies having interests or responsibilities relating to the project to coordinate field activities and monitoring with the State agencies and to keep them informed of Forest Service spray project plans. The meeting was held on July 1, 1968, at Olympia, Washington.

It was decided that monitoring of aquatic life would be carried out cooperatively by the Washington Department of Fisheries, the Washington Department of Game, and the U.S. Forest Service. Because of the relatively nontoxic nature of Zectran, its very short-lived existence in a toxic form, and the methods of application to be used, it was decided to hold monitoring of aquatic life to minimal efforts that would still provide the desired information.

g. Letters with information sheets on the proposed project, and requesting comments and/or participation, were sent out to the parties that would have an interest in the spray project as follows:

U.S. Fish & Wildlife Service
U.S. Public Health Service
U.S. Food & Drug Administration
U.S. Agricultural Research Service
Pacific Northwest Forest & Range Experiment Station
Pacific Southwest Forest & Range Experiment Station
U.S. National Park Service
Missoula Equipment Development Center
U.S. Weather Bureau
Washington Department of Game
Washington Department of Fisheries
Washington Department of Agriculture
Washington Department of Health
Washington Pollution Control Commission
Washington Department of Natural Resources
Skagit County Court
Snohomish County Court
Washington Sportsmens Council
Audubon Society
University of Washington
Northwest Forest Pest Action Council
Western Federation of Outdoor Clubs

h. Press releases on the project were sent out periodically preceding the project to keep the public informed, especially in the northwestern Washington area, including Seattle, Bellingham, and the smaller towns in the Skagit River vicinity.

i. Personnel from the Mt. Baker Forest and the Regional Office began an intensive effort to personally contact key groups and individuals.

j. An information digest on the hemlock looper, its damage potential, and the proposed project was prepared for distribution by the Mt. Baker Forest to any interested persons on a "help yourself" basis.

Administration.—A project outline was made up to cement procedures for the project and to use as an informational guide for contacts with other agencies and cooperators. (6)

An informational bulletin was prepared to describe the insect, what it does, how to control it, and minimize the damage it causes. (8)

The project study plan was reviewed and approved by the Washington Office and the Insecticide Evaluation Unit of the Pacific Southwest Station. (7)

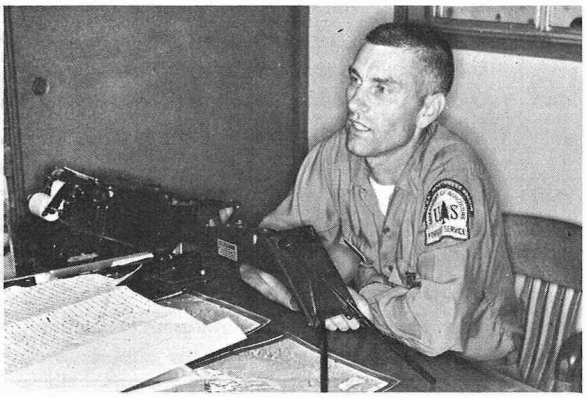


Figure 7.—Project entomologist using aerial photographs to locate spray areas and possible plot locations.

A summary of the biological effects of insecticides to be used on the project was made up as another informational tool for use with cooperators and the general public.

All possible information was gathered on the effects of Zectran and malathion on the natural resources and environment.

An entomological plan was made describing methods of determining egg numbers, larval numbers, mortality after spraying, and spray distribution.

Plans were made for providing communications, search and rescue in case of aircraft accident, and general safety on the project.

A plan of the organization to be used on the project was made, including organization charts and duties statements.

Spray system.—The project planners felt that a new type of spraying should be tested on the hemlock looper. This system, called "aerosol" spraying, was being developed jointly by the Insecticide Evaluation Unit of the Pacific Southwest Forest & Range Experiment Station and the Missoula Equipment Development Center. The system is composed of a bifluid unit utilizing freon, a common refrigerant gas (dichlorodifluoromethane) to break the insecticide down into very fine particles with a mass mean diameter less than 100 microns.

Since no one on the project was acquainted with the aerosol spray system, much coordination with personnel of both the Equipment Development Center and the Pesticide Evaluation Unit was required. Meetings

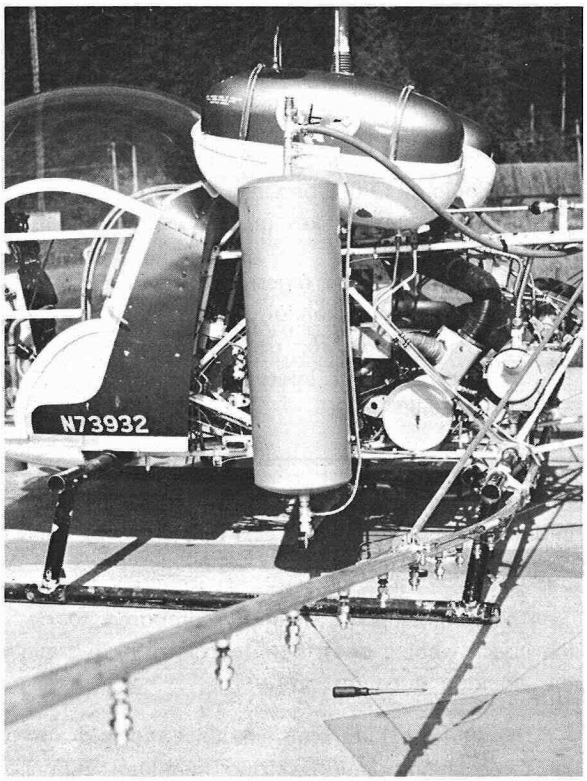


Figure 8.—View from left side of helicopter showing 12-nozzle spray boom and tank.

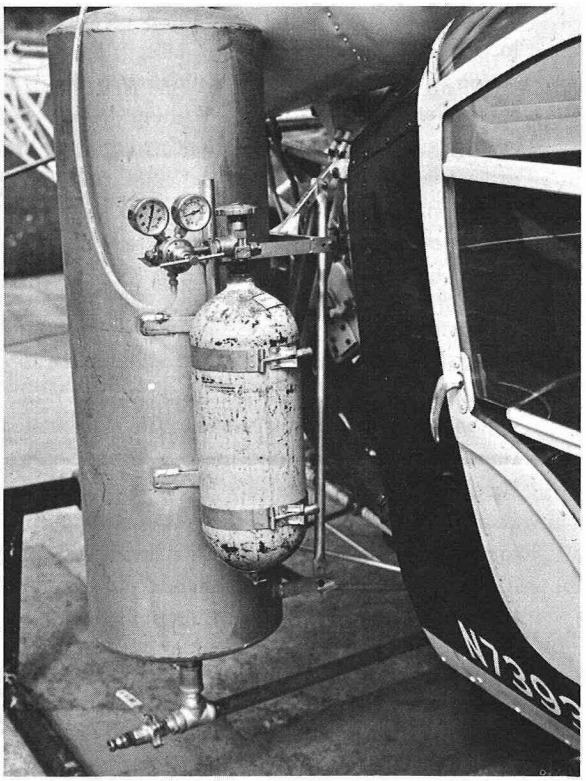


Figure 9.—Right-front view showing spray tank and nitrogen tank with pressure control gauges used to maintain pressure in system.

were held at Corvallis, Oregon and Missoula, Montana to discuss the use of this system, especially as it applies to helicopter spraying.

Coordination between the R-6 spray project and a somewhat similar project for spruce budworm control being planned by Region 1 was necessary. The helicopter spray apparatus was to be used by Region 1 as a backup for their fixed-wing system. The Region 6 operation was postponed by about 2 weeks since the equipment was being held in Missoula at the time the Region 6 project had been scheduled to start. Fortunately, in the case of the hemlock looper, the timing is not highly critical, and this delay had no known effect on the results of the project.

Weather conditions.—The aerosol system requires rather exacting weather conditions. The ideal condition is a temperature inversion during application, thus permitting mixing of the fine insecticide particles as the air warms up and the inversion begins to break up. Because of these exacting weather requirements, a Forest Service fire-weather meteorologist, Robert Lynott, was assigned as Project Meteorologist. His primary duties were to forecast general weather conditions as well as local conditions in the spray area. Arrangements were made for a mobile fire-weather station to be at project headquarters at the Marblemount Ranger Station to give current weather forecasts for the local area.

Another aid to determining proper weather conditions was a smoke generator mounted on the Forest Service observation helicopter (figure 10). This generator produced smoke by applying Corvus oil to the hot manifold and enabled prediction of where the spray was likely to go since the smoke and the fine spray particles act in a similar manner. Observation and evaluation of the smoke pattern was done by George Downing of the Insecticide Evaluation Unit.

The presence or absence of a temperature inversion was determined by means of a temperature probe. When temperatures at upper elevations are higher than at lower elevations, the spray will normally spread out rather than dissipate into the upper atmosphere, indicating the presence of an inversion layer.

Contracting.—The contract for application of the chemical on the project was awarded to Aerocopters, Inc., of Seattle, Washington, as low bidder. Bids were also received from two other helicopter operators. Significant features of the contract were:

(a) Forest Service spray equipment was to be used and would be mounted by Forest Service personnel.

(b) Standby time would be paid while equipment was being mounted.

(c) Minimum standby time equivalent to 2 hours per day flying time would be paid while Forest Service equipment was mounted on the helicopter.

Figure 10.—Smoke pattern from smoke generator on Forest Service helicopter.

(d) Since the equipment was designed for this model, the helicopter was to be of the Bell 47G-13B type.

(e) Spray area would be designated and marked by the Forest Service and payment would be on a per-hour basis.

Operation

The Marblemount Ranger Station on the Mt. Baker National Forest was established as headquarters for the project due to its proximity to the spray area and the fact that both radio and telephone communications, as well as a heliport, were available.

The Ranger District clerks handled most of the administrative detail, such as timekeeping for District crews, ordering supplies, and placing telephone calls. Insect checkers were stationed at project headquarters for approximately 6 weeks before spraying and the project entomologist was present during a major portion of this period.

Coordination and supervision of the project was done by the Insect and Disease Control Branch of the Division of Timber Management. Assistance in furnishing pilots and meteorologists for the project was provided by the Division of Fire Control. Through the cooperation of the Division of Range and Wildlife Management, the Siuslaw National Forest furnished a fishery biologist, Alvin Mills, for liaison with the State of Washington in monitoring chemical effects on salmon and the stream habitat. Liaison with other Forest Service Divisions and the other State agencies was handled by the Project Director and the Chief of the Branch of Insect and Disease Control.

Safety.—Plans were made covering communications, safety, and search and rescue. The communications plan included ground-to-ground, ground-to-air, and air-to-air communications and was integrated with the safety plan. The safety plan included flying and heliport operation, handling and applying insecticides, and safety of insect checkers, office personnel, and vehicle drivers. The search and rescue plan included preventive measures for helicopters and how to handle operations in case of a downed or missing aircraft.

These plans were distributed to all project personnel and safety was stressed throughout the operation. There were no accidents of any kind attributed to the project.

Physical characteristics of spray area.—Sonny Boy Creek is tributary to the Cascade River, an important fishing and recreational stream. About 12 miles downstream from Sonny Boy Creek the Cascade River flows into the Skagit River, a major salmon stream in the State of Washington.

Sonny Boy Creek is in a short, steep canyon with slopes averaging about 70% on the Mt. Baker National Forest. Because of the steepness of the topography in the area and lack of access, helicopter spraying was ideally suited to it. Helicopters were also used to transport insect checking crews and for marking the boundaries of the spray area.

The headwaters of Sonny Boy Creek are adjacent to the Glacier Peak Wilderness, about 2 miles from the spray area boundary. The elevation of the spray area averages about 2,800 feet, with ridges on either side rising to as much as 5,000 feet.

Organization.—During the peak of the operation, 17 Forest Service personnel were employed on the operation. These included four assigned from the Regional Office, Branch of Insect and Disease Control, two from the Division of Fire Control, one from the Siuslaw National Forest, one from the Berkeley Pesticide Evaluation Unit, one from the Missoula Equipment Development Center, and the remainder from the Mt. Baker National Forest. (See Organization Chart).

Marking of spray area.—Marking of the spray area was done using a method developed by John Wear and Benton Howard. (9) It consisted of using high-visibility fluorescent cloth cut into strips about 3 inches wide and 5 feet long. These strips were stapled onto a piece of heavy cord about 5 feet long at about 1-foot intervals. A large washer was attached to each end of the string. The entire assembly was then accordian pleated and bound with a rubber band.

After removing the rubber band, these markers were placed in the tops of tree crowns by throwing them out of a slow-moving helicopter. The washers wrap around the tree limbs and hold the markers in place. Markers were placed in a series of trees in a line at close intervals. They are highly visible from the air if placed at suitably close intervals, depending on topography, tree heights, and obstructions.

Spraying.—Since spraying was to be done by the aerosol method and equipment for this type of spraying

is not available commercially, the Forest Service furnished the spray equipment for the operation. They also provided all calibration of the spray system and mounted the equipment on the contract helicopter.

In addition to the actual spraying, this helicopter was used for marking of the area and transporting insect survey crews into the area prior to mounting of the spray equipment.

A Forest Service helicopter was used for administrative flying and for laying smoke, using the smoke generating apparatus previously described, before spraying.

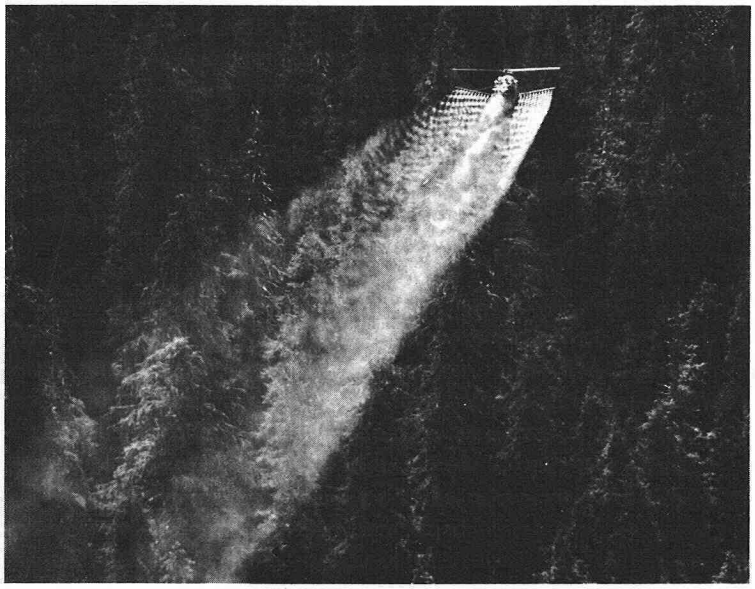


Figure 11.—Zectran being applied on the Sonny Boy Creek watershed while helicopter flies up canyon.

The original spray date was set for July 8, but since the spray equipment was being used in Region 1, the date was changed to July 18. Smoke checks of the area were run on July 17 to determine the air patterns in the Sonny Bay Creek drainage. On July 18, rain began at about 7:00 a.m. and the spray date was again postponed until July 23. Spraying began at 7:30 a.m. on July 23 and was completed by noon.

Only two problems occurred during the actual spraying operation. First, a malfunction in the spray system trigger necessitated spraying in one portion of the area several times because of intermittence in the spraying. The second was a malfunction of a warning light on the observation helicopter which caused it to miss two trips with the spray helicopter. It is unlikely that either incident caused any major changes in the results attained.

The weather during the spray operation was clear except for a few clouds on the higher ridges early in the day. When spraying first began there was no detectable wind, but by the time it was completed, the wind was up to about 5 miles per hour at spray level.

Loading spray material into the helicopter was carried out at a helispot located just across the Cascade River from the spray area (figure 15). A good portion of the spray area could be viewed directly from the helispot. Flying time from the helispot to the spray area was less than 2 minutes and round trip time, including spraying, averaged only about 12 minutes.

Figure 12.—Aerial view of spray helicopter being loaded with Zectran at temporary helispot used as a base of operations.

The tank capacity for the spray system was 60 gallons, of which almost half was freon refrigerant gas. A total of 155 gallons of Zectran-TPM solution mixed with 115 gallons of freon was applied. Each gallon of Dowanol TPM carrier contained 1/2 pound (6% by weight) of the active insecticide, Zectran. The spray operation required eight trips, but because of the malfunction of the trigger mechanism, no spray was applied on one of these trips.

Spray distribution.—The average volume per acre actually applied was 2.48 pints which was slightly more than the planned 2.4 pints per acre. This was because of some respraying necessary due to the faulty trigger mechanism.

Coverage of the area was very good and the spray appeared to be dropping into the trees as desired. Except for two trips when the warning light was not working, the observation helicopter monitored every load and kept track of where the spray appeared to be going.

No proven method for quantitatively monitoring spray patterns was available due to the extremely small droplets.

Cooperation

Information on previous Zectran testing was provided by the U.S. Fish and Wildlife Service of the Department of Interior.

The U.S. Department of Commerce Weather Bureau furnished a meteorologist and a mobile weather station to work with the Forest Service meteorologist on the project. This provided the Project Director with up-to-date weather information for the local area several times each day.

Assistance in egg sampling was provided by the State of Washington Department of Natural Resources. Egg samples were taken on State and private lands in the general surveillance area by Washington State entomologists.

CONCLUSIONS AND RECOMMENDATIONS

Recommendations from other aerial spray projects throughout the Nation were carefully reviewed and pertinent items incorporated in this project. In addition to those recommendations previously reported, the following items are recommended for review in future aerial projects:

1. A simpler method of obtaining fine droplets is needed if aerosol spraying is going to be used on major spray projects involving helicopter spraying. The present procedure of mixing freon with insecticide is cumbersome and the freon takes up a considerable amount of the capacity of the helicopter that could be better used for insecticide.
2. More research needs to be done on methods for spray assessment of the very fine droplets produced by the aerosol system.
3. Until further study has been made of effects of air currents on aerosol sprays, application should be by the swathing system. Too much valuable spraying time may be wasted waiting for ideal conditions for application by air currents.
4. As much time as possible should be allowed for materials to be delivered. Last minute transportation problems sometimes cause delays which could materially affect the project.
5. Radios in aircraft should be double checked before the project starts. The assumption that because a radio is installed permanently in an aircraft it is in working condition is not always valid.
6. Some method of predicting larval populations from egg counts should be developed.
7. Pre- and postspray sampling methods in old-growth timber need further study. It is not known whether sampling of vegetation beneath the crown or in the lower crown gives the best estimate of insect mortality throughout the crown.
8. The results of this test bring up some serious questions about the feasibility of using this spray method in heavy old-growth stands. Interception by tree crowns appears to be a serious problem in stands of this type.
9. Due to the low mortality level obtained by spraying Zectran at 0.2 pounds per acre, we do not recommend its use as a control agent for the hemlock looper at this formulation. Further studies should be made at higher concentrations to determine if adequate control at an economical level can be obtained with Zectran.

BIBLIOGRAPHY

(1) Buffan, Paul E.
1964. Pilot test results of Sevin, Phosphamidon, and DDT on the western hemlock looper in southwest Washington in 1963. Pacific Northwest Region, U.S. Dept. Agr., Forest Service. 41 pp, illustrated.

(2) ————————
1963. Summarization report of the technical aspects of the 1962 western hemlock looper control project at Astoria, Oregon. U.S. Forest Serv., Pacific Northwest Region, Div. of Timber Mangt., 19 pp.

(3) ————————
1964. Results of the 1963-64 western hemlock looper egg survey in western Washington. U.S. Forest Serv., Pacific Northwest Region, Div. of Timber Mangt., 4 pp.

(4) Fink, Clifford R.
1963. Plan of operation for pilot tests of Sevin, Phosphamidon, and *Bacillus thuringiensis* against the western hemlock looper in southwest Washington in 1963.

(5) Hemlock Looper Study Committee
1964. Status report, 1963 Willapa hemlock looper infestation control project. State of Washington. 74 pp., illus.

(6) Mounts, Jack
1968. Project outline — field test of two insecticides against the hemlock looper, Mt. Baker National Forest, Washington. U.S. Forest Serv., R-6, 5 pp.

(7) ————————
1968. Project study plan — field test of two insecticides against the hemlock looper, Mt. Baker National Forest, Washington. U.S. Forest Serv., R-6, 6 pp.

(8) Pettinger, Leon F.
1968. Entomological aspects of the pilot test of Zectran and Malathion against the western hemlock looper on the Mt. Baker National Forest, Washington. U.S. Forest Serv., R-6, 10 pp.

(9) Wear, John F., and Benton Howard
1966. New tree marking system improves forest spraying operations. Pacific Northwest Region, U.S. Dept. Agr., Forest Service, 8 pp.

APPENDIX

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STATISTICAL SUMMARY

Cost per Acre

Insecticide and other chemicals	$ 4.58
Other materials	1.82
Aircraft	9.11
Administration	21.20
Total cost per acre	36.71
Total acres sprayed	500
Total cost of project	$18,358.00

Chemicals applied

Gallons of insecticide (6% Zectran in TPM)	155
Gallons of freon (dichlorodifluoromethane)	115
Total gallons	270
Gallons per acre	0.54

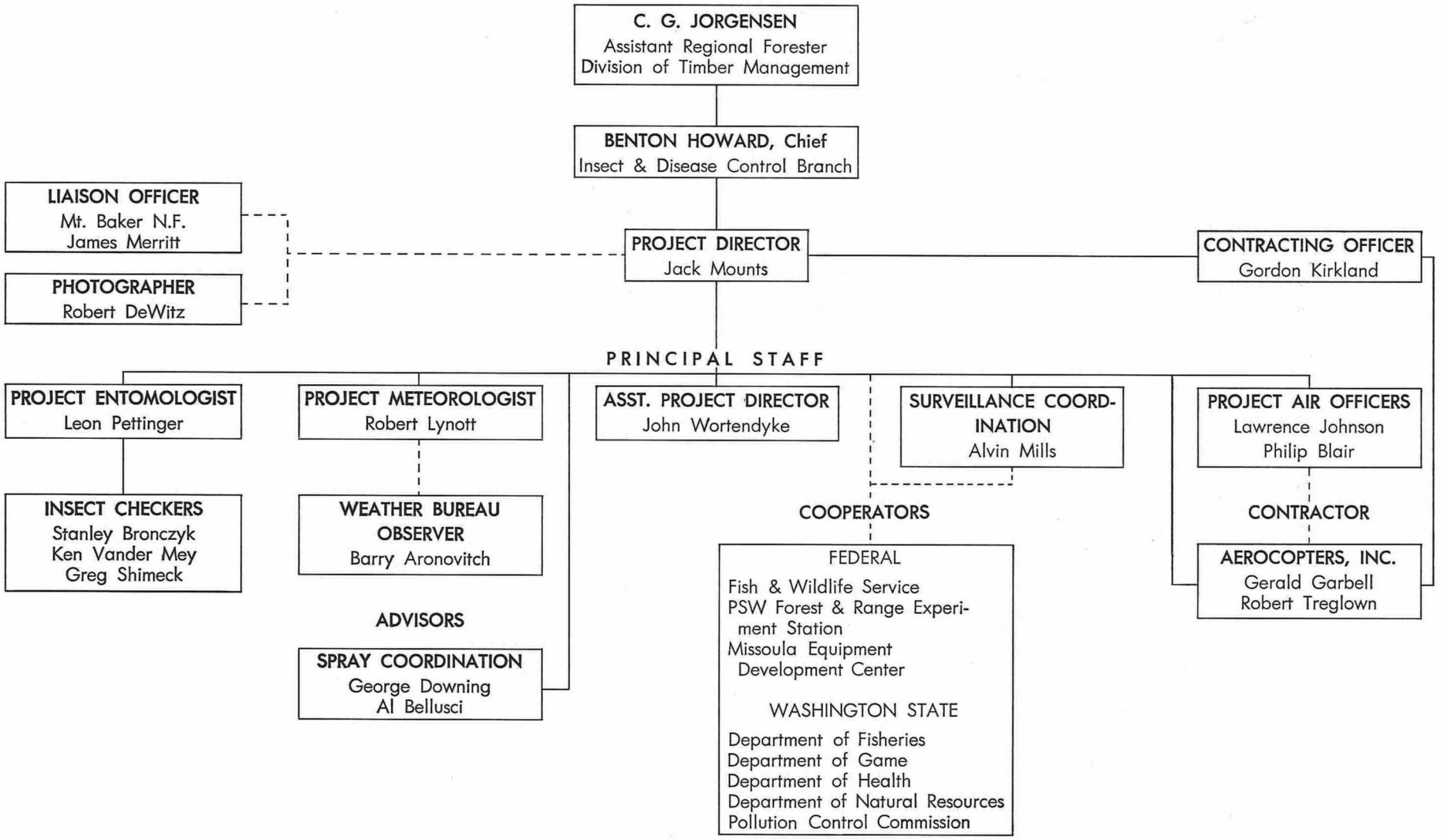
Aircraft Hours

Contract helicopter (Bell 47-G3B1)	16:37
Forest Service helicopter (Hiller 12E4)	15:00
Forest Service, other	29:06
Total aircraft hours	60:43

Manhours Worked (Forest Service personnel)

Planning phase	850
Biological phase	300
Operational phase	350
Total Manhours worked	1,500

ORGANIZATION — HEMLOCK LOOPER PROJECT



LIST OF FOREST SERVICE PERSONNEL

Name	Project Title	Duties	Organization
Jack Mounts	Project Director	Planned and supervised entire project. (Spray contract C.O.R.)	Regional Office, Timber Management
Leon F. Pettinger	Project Entomologist	Planned and supervised all entomological phases of the project.	Regional Office, Timber Management
John T. Wortendyke	Assistant Project Director	Planned and supervised supply, communications, safety, and timekeeping phases of project.	Regional Office, Timber Management
Robert E. Lynott	Project Meteorologist	Planned and supervised weather information phases of project.	Regional Office, Fire Control
Philip G. Blair and Lawrence Johnson	Project Air Officer	Advised project director on aerial phases of project and piloted observation helicopter.	Regional Office, Fire Control
Alvin D. Mills	Fishery Biologist	Coordinated monitoring of effects of insecticide on fish with State of Washington biologists.	Siuslaw National Forest
George Downing	Entomologist	Provided technical direction of aerosol spraying techniques and monitoring of spraying.	Pacific Southwest Forest & Range Experiment Station
Al Bellusci	Engineering Technician	Supervised spray equipment installation and loading operations.	Missoula Equipment Development Center
James Merritt	Liaison Officer	Coordinator for Mt. Baker National Forest.	Mt. Baker National Forest
Robert Dewitz	Photographer	Provided photographic record of entire project.	Mt. Baker National Forest
Kenneth Vander Mey	Insect Checker	Set up and read prespray and postspray plots and took egg samples.	Mt. Baker National Forest
Stanley Bronczyk	Insect Checker	Set up and read prespray and postspray plots and took egg samples.	Regional Office, Timber Management
Bryson Lausch & District personnel	District Ranger	Assistance with transportation, supply, clerical work, etc.	Skagit Ranger District Mt. Baker National Forest

LIST OF CONTRACT PERSONNEL
(Aerocopters, Inc.)

Name	Title	Duties
Gerald Garbell	Owner-Chief pilot	Flying spray helicopter
Robert Treglown	Pilot	Flying crews and area marking

PESTICIDE EVALUATION PROJECT PERSONNEL
(PSW, Berkeley, California)

Name	Title
Dr. Arthur D. Moore	Project Director
George Downing	Entomologist
Dr. Carroll Williams	Entomologist
Patrick Shea	Entomologist

MISSOULA EQUIPMENT DEVELOPMENT CENTER PERSONNEL

Name	Title
Arthur J. Mattila	Test Section
Anthony E. Jasumback	Mechanical Engineer
Al Bellusci	Mechanical Engineer

LIST OF COOPERATORS

Agency	Representatives
Federal	
Bureau of Commercial Fisheries	George M. Kaydas
National Park Service	John M. Mahoney
Bureau of Sport Fisheries & Wildlife	Delbert H. Rasmussen
Water Pollution Control Administration	James L. Agee
U.S. Geological Survey	Stanley Kapustka
Agricultural Research Service	Harold B. Busdicker
Washington State	
Department of Fisheries	E. H. LeMier, Russell Orell, Walt Williams, & Jim Haines
Department of Natural Resources	Donald Hopkins, Rick Johnsey
Department of Game	Louis Lund, Jack Ayerst
Pollution Control Commission	George Hanson, Ronald Lee
Department of Health	Sam Reed, Bernard Bucove, M.D.
University of Washington, Fisheries Research Institute	Dr. William F. Royce

Table 1.—Helicopter time and spray volume record

Trip No.	Gallons Zectran per trip	Cumulative gallons Zectran	Gallons Freon per trip	Cumulative gallons Freon	Take off time (hours)	Land time (hours)	Flying time per trip (minutes)	Cumulative flying time (minutes)	Remarks
1	17	17	13	30	0730	0738	8	8	Valve problems, no spraying done
2	--	--	--	47	0750	0801	11	19	(same load)
3	23	40	17	64	0904	0915	11	30	
4	23	63	17	81	0936	0954	18	48	Longer time due to altitude gain
5	23	86	17	98	1016	1028	12	60	
6	23	109	17	115	1041	1053	12	72	
7	23	132	17	--	1106	1118	12	84	Minor valve problems
8	23	155	17	13	1137	1149	12	96	
Totals	155	--	115	--	--	--	96	--	1:36 Total time

Figure 13.—Temperature profile over spray area

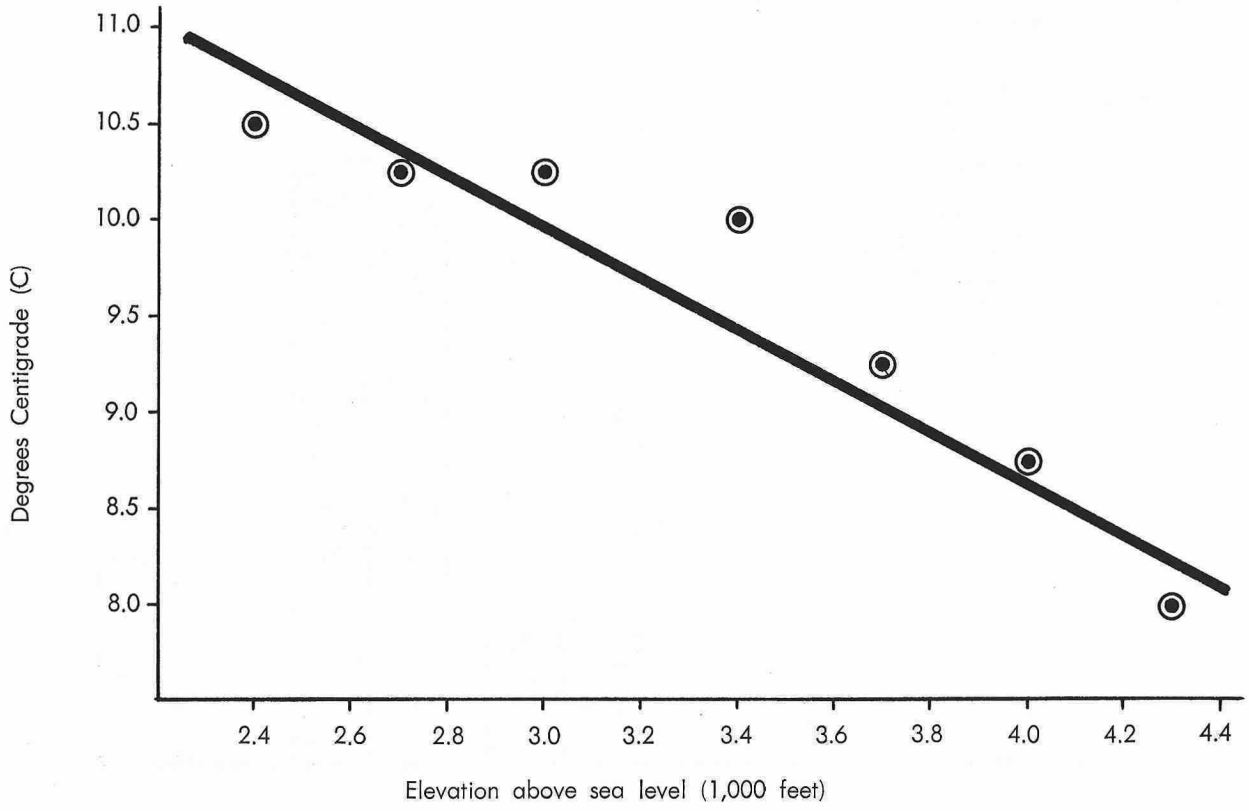


Table 2.—Spray deposit data on oil-sensitive cards

Line No.	Sample point No.	Card No.	Indications of spray deposit[1]	Position of card in canopy[2]	Percent population change[3]
1	1	204	N	C	76.2—
1	2	205	N	C	12.5+
1	3	206	N	C	25.8—
1	4	203	N	C	80.0+
1	5	202	N	C	42.9—
3	3	50	N	C	18.2—
3	3	51	N	C	18.2—
3	5	52	S	O	50.0—
3	5	53	Y	O	50.0—
3	6	54	Y	O	9.1—
3	6	55	Y	O	9.1—
3	6	56	Y	O	9.1—
3	7	57	N	C	5.9—
3	7	58	N	C	5.9—
3	9	59	S	C	30.0—
3	9	60	S	C	30.0—
3	11	61	N	C	40.0—
3	11	62	S	C	40.0—

[1] N = None, S = Slight, Y = Yes
[2] C = Covered, O = Open
[3] (+) = Increase, (—) = Decrease

Table 3.—Western hemlock looper population data

Line No.	Point No.	Larval count		Percent change	
		Prespray	Postspray	Increase	Decrease
1	1	63	15		76.2
1	2	40	45	12.5	
1	3	62	46		25.8
1	4	25	45	80.0	
1	5	35	20		42.9
Subtotal		225	171		24.0
2	1	35	55	57.1	
2	2	62	47		24.2
2	3	30	29		3.3
2	4	31	10		67.7
2	5	16	14		12.5
2	6	15	17	13.3	
2	7	16	22	37.5	
2	8	51	34		33.3
Subtotal		256	228		10.9
3	1	15	8		46.7
3	2	21	18		14.3
3	3	11	9		18.2
3	4	13	6		53.8
3	5	28	14		50.0
3	6	11	10		9.1
3	7	17	16		5.9
3	8	19	15		21.1
3	9	10	7		30.0
3	10	12	13	8.3	
3	11	27	16		40.7
Subtotal		184	132		28.3
Total		665	531		20.1

Figure 14.—Development of western hemlock looper larvae during the pilot test.

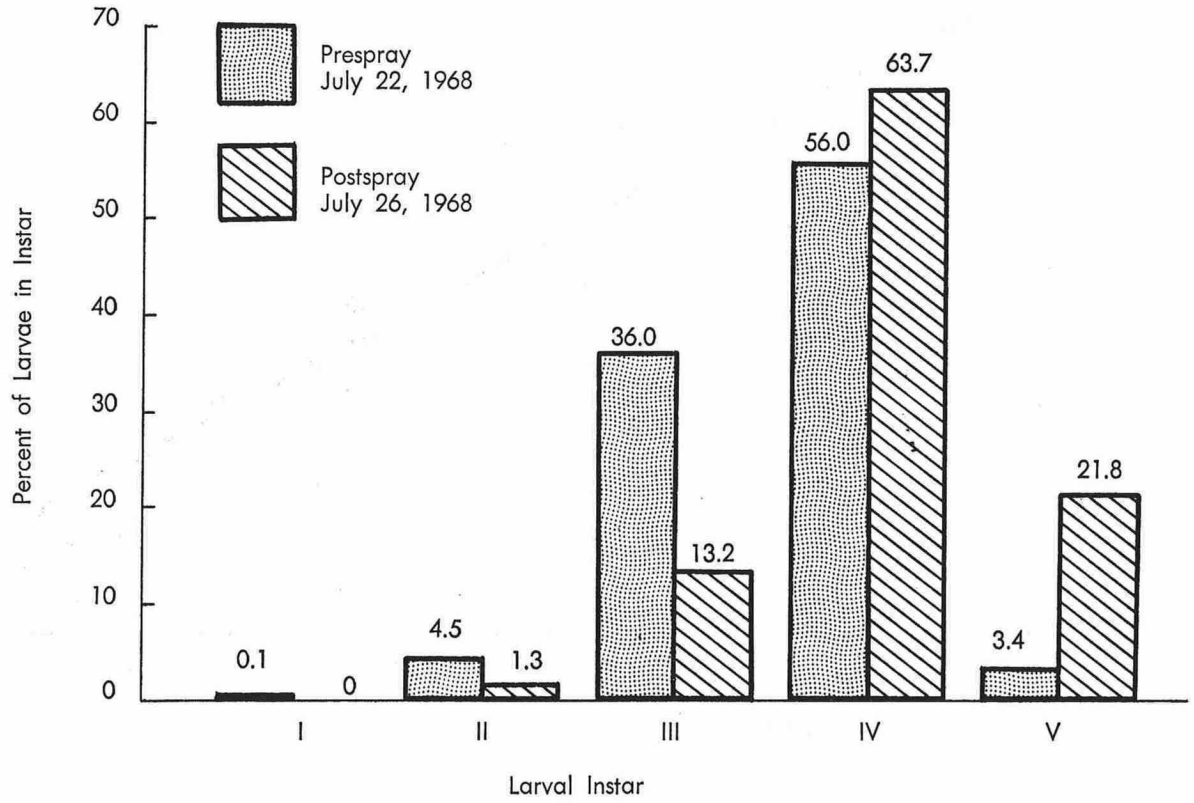


Table 4.—Other insect population data[1]

Line No.	Larval Count		Percent Change	
	Prespray	Postspray	Increase	Decrease
1	13	10		23.1
2	43	51	18.6	
3	51	74	45.1	
Total	107	135	26.2	

[1] Hemlock sawfly and black-headed budworm.

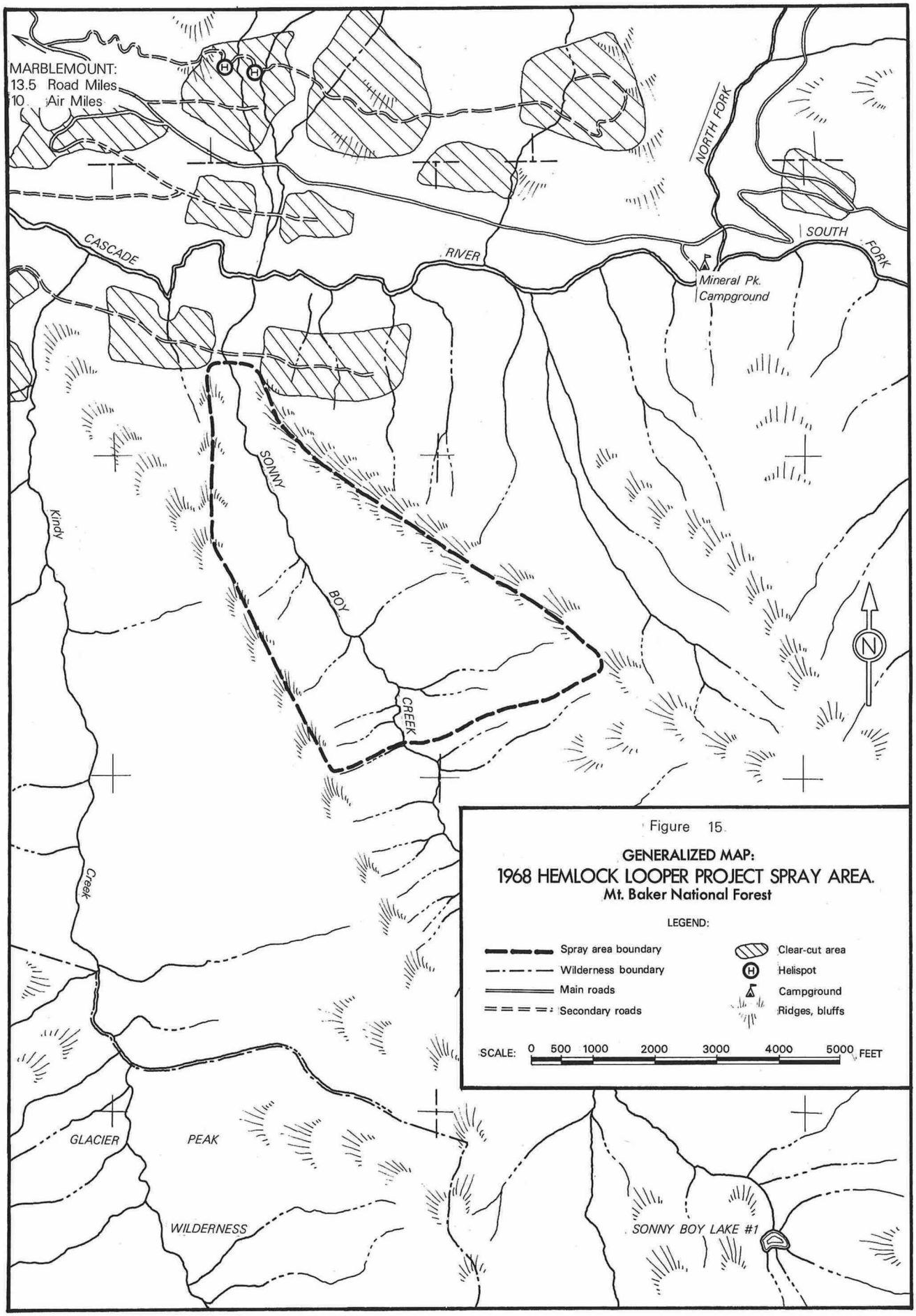
BID SUMMARY

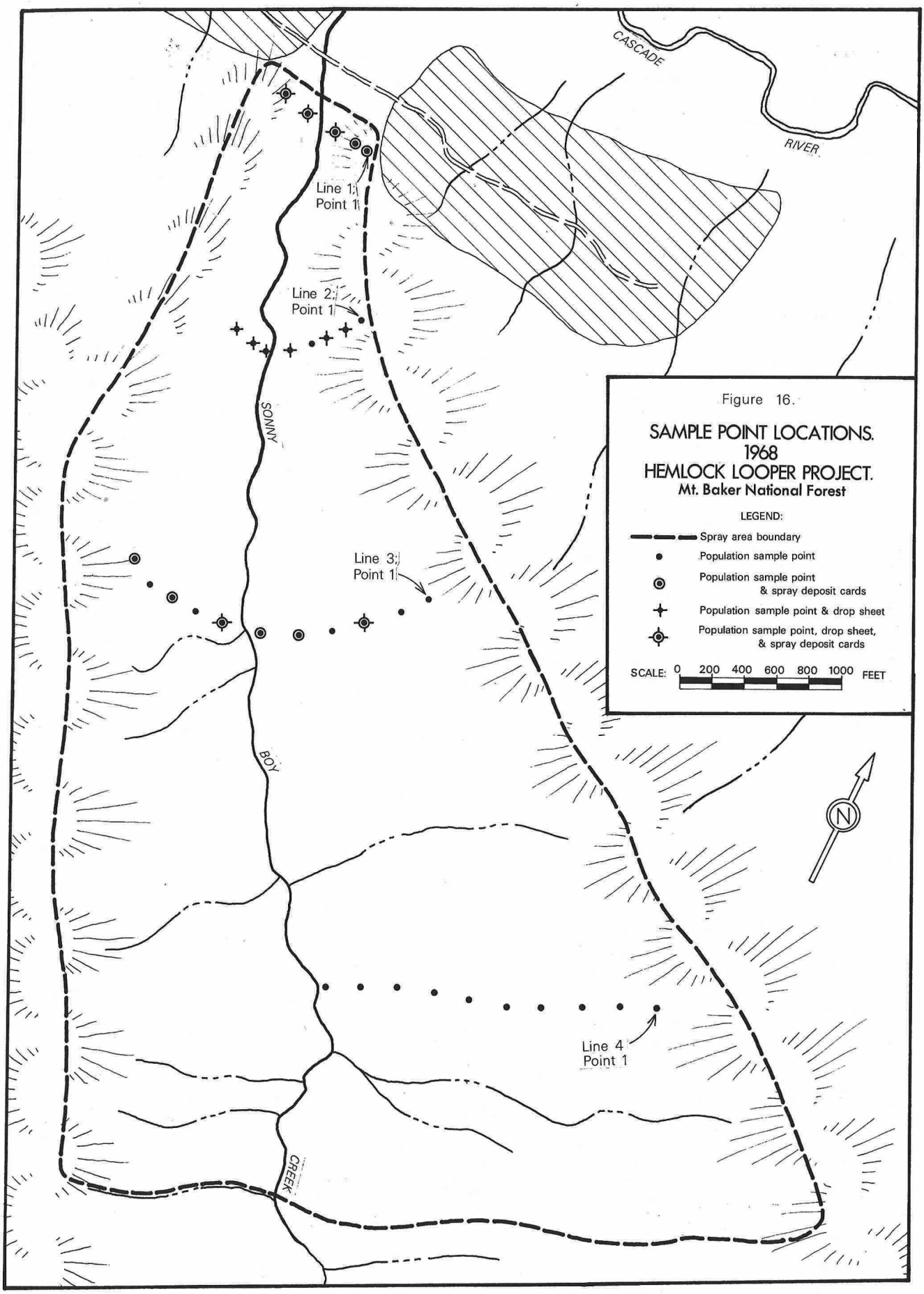
Bidder	Bid Rate	Total Bid Price
Aerocopters, Incorporated	$150/hour	$3,000.00
Willamette Helicopter Service	$156/hour	$3,120.00
Cascade Helicopter Service	$179/hour	$3,580.00

Successful Bidder	Hours on Project	Total Cost
Aerocopters, Incorporated	16:37	$2,492.50

Table 5.—Project cost summary

Item	Cost				
	Planning phase	Biological phase	Operational phase	All phases	Per acre
	Dollars				
Salaries (F.S. personnel)	3,141	1,913	2,471	7,525	15.05
Per diem and travel	1,057	771	1,246	3,074	6.15
Contract helicopter	0	0	2,493	2,493	4.98
Forest Service aircraft:					
Helicopter	0	0	1,425	1,425	2.85
Other	640	0	0	640	1.28
Chemicals					
Zectran	0	0	1,626	1,626	3.25
Freon	0	0	600	600	1.20
Liquid Nitrogen	0	0	64	64	.13
Materials and transportation	56	80	775	911	1.82
Project Totals	4,894	2,764	10,700	18,358	36.71
Per acre Totals	9.78	5.53	21.40	36.71	--


MARBLEMOUNT:
13.5 Road Miles
10 Air Miles
CASCADE
RIVER
NORTH FORK
SOUTH FORK
Mineral Pk.
Campground
SONNY
BOY
CREEK
Kindy
Creek
GLACIER
PEAK
WILDERNESS
SONNY BOY LAKE #1
N
Figure 15.
GENERALIZED MAP:
1968 HEMLOCK LOOPER PROJECT SPRAY AREA.
Mt. Baker National Forest
LEGEND:
Spray area boundary
Wilderness boundary
Main roads
Secondary roads
Clear-cut area
Helispot
Campground
Ridges, bluffs
SCALE: 0 500 1000 2000 3000 4000 5000 FEET


CASCADE
RIVER
Line 1, Point 1
Line 2, Point 1
SONNY
Line 3, Point 1
BOY
Line 4 Point 1
CREEK
Figure 16.
SAMPLE POINT LOCATIONS. 1968 HEMLOCK LOOPER PROJECT.
Mt. Baker National Forest
LEGEND:
Spray area boundary
Population sample point
Population sample point & spray deposit cards
Population sample point & drop sheet
Population sample point, drop sheet, & spray deposit cards
SCALE: 0 200 400 600 800 1000 FEET
N

NATIONAL FOREST SYSTEM
COOPERATIVE FORESTRY
FORESTRY RESEARCH
FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE

GPO 995-506